

Rock Chips

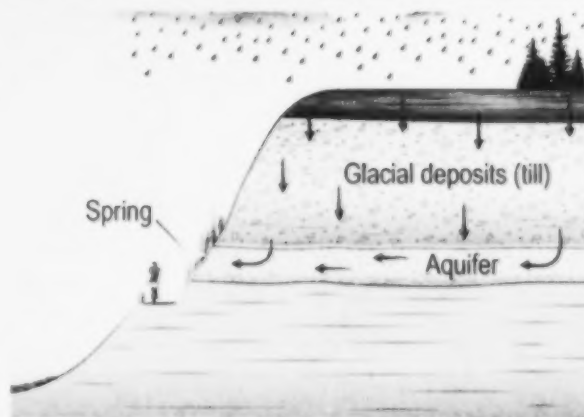
Spring 2009

GIS Information on Springs Now Available

The eminent hydrogeologist Oscar Meinzer defined a spring as "a place where, without the agency of man, water flows from a rock or soil upon the land or into a body of surface water." Springs have also been described by another eminent hydrogeologist, Peter Meyboom, as "groundwater outcrops." It is difficult to understand the phenomenon of springs without some understanding of their source. People frequently picture groundwater flowing as 'underground rivers.' Although water can and does flow as rivers underground in certain circumstances and in specific parts of the world, groundwater occurs within the pore spaces between grains of sand or sediment that make up the matrix of the ground beneath our feet. For the most part, the only way to access these materials is by digging or drilling a well. The water that resides within the rock or soil can then be pumped out of the well for consumption or scientific investigation. There is, however, another way to learn about groundwater.

In many places, erosion has carved out valleys that intersect some of the shallower intervals of saturated rock or soil; for example, by rivers. It is at these intersections that we may see a spring. Water may flow out of the intersected rocks or soil periodically, or continuously, depending on the lateral extent of these materials and how often rainfall percolating through the earth replenishes the rocks or soil. As the water moves through the pore spaces, it dissolves minerals and carries them to the spring outflow; often the minerals are deposited when the water exits.

By measuring the spring's changes in flow volume over time and the chemical constituents in the water, we can tell a great deal about groundwater flow and the rocks or soil hosting the water. Knowing the locations of the springs throughout the province provides the first step in understanding groundwater – all without drilling a well.



Schematic showing one example of a relationship of springs to aquifers.



Measuring spring flow volume using a weir on the Wiau springs northwest of Wandering River.

With this goal in mind, Alberta Geological Survey (AGS) completed a major compilation project of springs data, resulting in the release of a digital dataset (DIG 2009-0002). This Geographic Information System (GIS) dataset contains location information of many of the springs in Alberta, from both published and unpublished maps and reports. The locations were digitized from 48 1:50 000-scale Alberta Hydrogeology Information Map Series maps created by the Alberta Research Council (ARC) in the 1960s and 1970s.

Between 1967 and 1982, the ARC released numerous Earth Sciences Reports on the hydrogeology of Alberta. Hydrogeologists took care to include the location of any springs on the maps that accompanied the reports. On occasion, they would also describe some of the large springs within their given study areas.

In 1983, the ARC released Earth Sciences Report 1982-03, Springs of Alberta, written by Dominique Borneuf. This report has information on approximately 600 springs in Alberta, with some information dating back to 1898. This report provides a description of the larger or better-known springs, and tables of data that provide a location, flow rate, chemistry data and any pertinent information about the spring.



AGS staff member Sheila Stewart performing an alkalinity analysis at the Wiau springs.

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Raven Fish Hatchery spring near Raven, in southwestern Alberta.

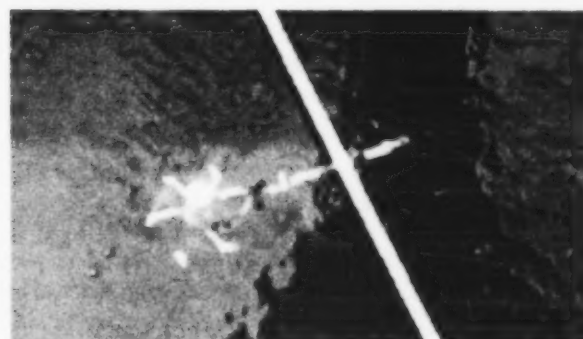
In 2002, AGS began work on a large spring complex in northeastern Alberta, named the Wiau springs. Flow from these springs enters the Athabasca River along a number of points with an average cumulative flow of 7700 m³/d in 2000-2001. Geo-Note 2002-06 provides details of the discharge and water chemistry of these springs.

In 2005, AGS completed a groundwater resource appraisal in the Cold Lake – Beaver River Drainage Basin. In this report, AGS discussed the springs present in the basin in the context of understanding groundwater flow in this region. We published the results in Special Report 074.

Springs are interesting features on our landscape. They offer a glimpse into a resource that we normally cannot see because it resides beneath our feet. The recent AGS digital release and reports mentioned above provide valuable information for those interested in learning more about these groundwater outcrops. You can access them at www.ags.gov.ab.ca/publications. ❖



AGS staff member Gordon Jean using a flow meter in the channel of the Wiau spring.



A close-up of the flow meter in the spring.



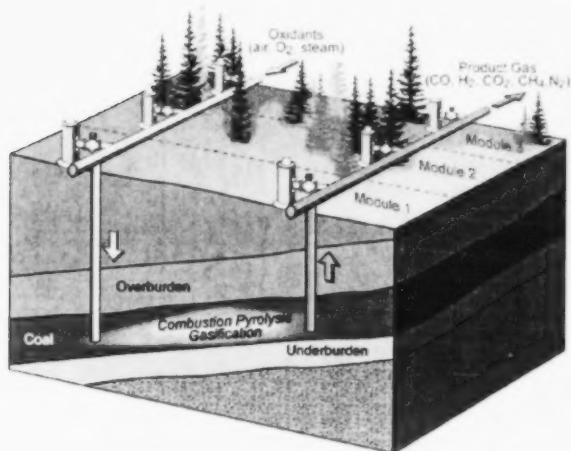
Measuring the width of the channel to calculate flow volume.

Underground Coal Gasification Potential in Alberta

Alberta produces approximately 50% of its electricity from coal-fired generating stations and approximately 40% from gas-fired generators. Declining reserves and the associated increasing cost of oil and gas has prompted industry to look at alternative sources of energy. Alberta contains a great amount of coal resources at shallow depths (in excess of 33 billion tonnes) that facilitate economical power generation; however, there are huge coal resources at depth that are currently not economic to mine. This represents a large untapped potential energy source for the province.

From the late 1800s to the early 1900s, gas (mainly carbon monoxide and hydrogen) derived from coal conversion was used for heating and lighting throughout the world. Surficial coal gasification was used to produce fuel during World War II, and many countries continue to produce fuels and chemicals from coal to this day. Most large-scale coal gasification processes involve reacting coal in a large surface chamber (reactor vessel) at high temperature and pressure with steam and a limited amount of oxygen to prevent combustion. The coal reacts with the steam and oxygen, producing synthesis gas ("syngas") and ash residue remaining from the mineral matter in the coal.

An alternative to surficial gasification is underground coal gasification (UCG). This process differs from surficial gasification in that the coal is not mined, rather the deep underground coal seams themselves (which may be too deep to mine) serve as the reactor vessel.



Underground coal gasification scheme (modified from www.fossil.energy.gov/international/Publications/cwg_april06_ucg_reliance.pdf).

A UCG operation consists of a series of injection and production wells drilled into a coal seam. The coal is ignited, and air and/or oxygen is injected. Chemical reactions convert the coal to syngas by pyrolysis, combustion and gasification reactions in a manner similar to those processes in a surficial gasifier. The produced syngas is a mixture of mainly carbon monoxide and hydrogen, which can be used as fuel in direct power generation, as well as feedstock for various chemical products (i.e., hydrogen and ammonia) and as synthetic pipeline gas, a replacement for natural gas. Syngas also represents a viable source for hydrogen, which has been suggested to be the "next generation fuel" to replace gasoline in the future. The main UCG by-products are in situ deposits (roof-rock fragments and ash-rubble in the void space underground where the coal was consumed) and flue gases and fly-ash entrained in the syngas stream, which are subsequently captured and managed as a part of the power or chemical plant system. Emissions from syngas combustion are generally cleaner and produce less greenhouse-gas emissions than coal-fired facilities.

The UCG process is less costly than the conventional surficial coal gasification, as no coal mining, processing or transport is involved and no ash/slag removal or disposal is necessary. The environmental impact of UCG is low and manageable, as no extensive air pollution, and no surface disposal of ash and coal tailings are associated. A properly designed site will recognise and reduce potential effects to groundwater and risks of subsidence.

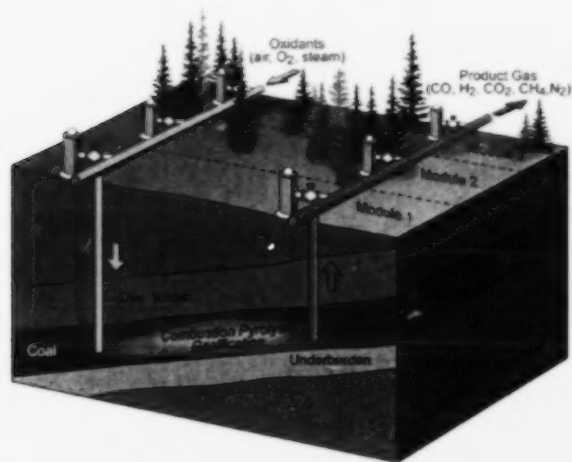
Coal studies in Alberta suggest that portions of the Ardley, Horseshoe Canyon and Upper Mannville coal zones in the central part of the province may be suited for UCG. These central Alberta coals have similar properties to coal already being subjected to UCG elsewhere in the world. They are of sub-bituminous rank (vitrinite reflectance between 0.5% and 0.6% R_o) with thicknesses greater than 500 cm, occurring at depths greater than 30 m, are generally flat-lying and have extensive continuity. Many central Alberta coals occur in multiple-seam packages with calorific values and coal reactivity parameters (average amount of vitrinite + exinite/liptinite > 60%, volatile matter > 35%) conducive to the gasification process. Ongoing studies by Alberta Geological Survey produce information on coal geology, quality, composition and distribution. This information can help predict site suitability and UCG potential, and assist the Alberta government in regulation of this industry. ❖

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- some ERCB publications;
- approximately 3000 Geological Survey of Canada maps;
- a microfiche collection of more than 1000 Alberta Mineral Assessment Reports; and
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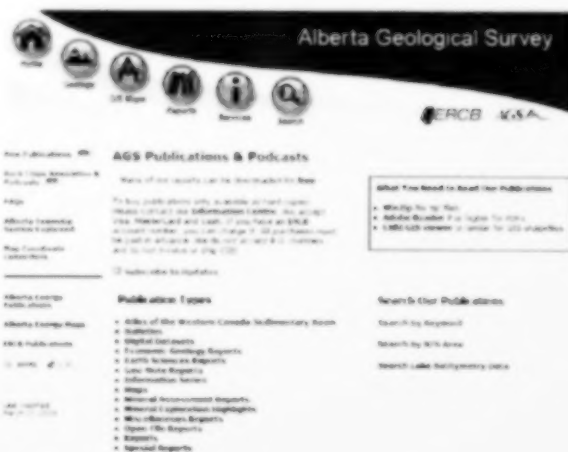
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Recently Released Publications

Digital Datasets

DIG 2009-001 Geochemical Data from Bad Heart Formation, Northwestern Alberta (tabular dataset)

DIG 2009-002 Alberta Spring Locations (GIS data, point features)

Maps

MAP 420 Surficial Geology of the Cameron Hills Area (NTS 84N/NW). 4.96 MB PDF. \$20.00.

MAP 422 Surficial Geology of the Cleardale Area (NTS 84D/SW). 3.00 MB PDF. \$20.00.

MAP 423 Surficial Geology of the South Whitesand River Area (NTS 84O/S). 3.56 MB PDF. \$20.00.

Open File Reports

OFR 2008-11 Rock Eval®, Total Organic Carbon, Adsorption Isotherms and Organic Petrography of the Colorado Group: Shale Gas Data Release. 26.06 MB PDF. \$20.00.

OFR 2008-12 Rock Eval®, Total Organic Carbon, Adsorption Isotherms and Organic Petrography of the Banff and Exshaw Formations: Shale Gas Data Release. 24.8 MB PDF. \$20.00.

OFR 2008-13 Mineralogy, Permeametry, Mercury Porosimetry and Scanning Electron Microscope Imaging of the Banff and Exshaw Formation: Shale Gas Data Release. 39.33 MB PDF. \$20.00.

OFR 2008-14 Mineralogy, Permeametry, Mercury Porosimetry and Scanning Electron Microscope Imaging of the Colorado Group: Shale Gas Data Release. 87 MB PDF. \$20.00.

OFR 2009-01 Geochemistry and Preliminary Stratigraphy of Ooidal Ironstone of the Bad Heart Formation, Clear Hills and Smoky River Regions, Northwestern Alberta. 191 MB PDF. \$20.00.

OFR 2009-03 Geochemical and Petrographic Evaluation of Downhole Gamma-Ray Anomalies in the Buffalo Head Hills Kimberlite Field, North-Central Alberta (NTS 84B/13). 16.46 MB PDF. \$20.00.

OFR 2009-05 Implementation of a Web-GIS Application for the Turtle Mountain Monitoring Project in ArcGIS® Server 9.2. 2.48 MB PDF. \$20.00.

OFR 2009-07 Surficial Geology and Quaternary History of the High Prairie Area, Alberta (NTS 83N/SE). 33.01 MB PDF. \$20.00.

Story Contact Information

The following AGS staff members may be contacted for further information on their articles or citations.

GIS Information on Springs Now Available

Metals Potential of Igneous Rocks in Alberta...

Underground Coal Gasification Potential in Alberta

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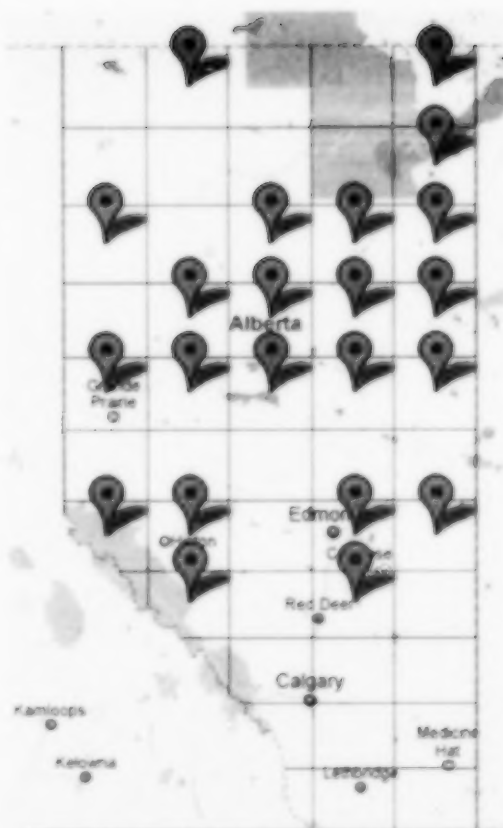
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Core Holdings

Alberta Geological Survey has approximately 650 mineral exploration core samples from various locations in Alberta. These samples are available for viewing at our Mineral Core Research Facility in Edmonton. Core location, description, targets, depth and cross-references with relevant mineral assessment reports are available. www.ag.gov.ab.ca/mcrf

Mineral Assessment Reports

Alberta Geological Survey is pleased to announce a major initiative was undertaken to provide free digital access to mineral assessment reports on behalf of the Alberta Department of Energy. Reports cover the period from 1949 to 2008. Approximately 500 reports are now available as PDFs, reproduced from the original reports. www.ag.gov.ab.ca/publications



Interactive map on AGS website showing core holdings at the MCRF. www.ag.gov.ab.ca/mcrf/core_map.html



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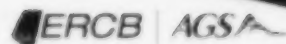


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| MIN 20080007 | Assessment Report for the Call of the Wild Property, Northern Alberta Apex Geoscience Ltd.; Stormway Diamonds Corp.; Grizzly Diamonds Ltd.; Dufresne, M.B., 2008. |
| MIN 20070029 | 2006 Mineral Exploration Activities on the St. Paul Project, East-Central Alberta 1197313 Alberta Ltd.; Diamondex Resources Ltd.; Jalbert, R.; Clarke, D.; Weir, K.J., 2006. |
| MIN 20070028 | Knelsen Wapiti River South - Potential of Bedrock Depths for Recovery as a Component for Concrete Knelsen Rock Products G.P. Ltd.; Torstensen, V., 2007. |

Metals Potential of Igneous Rocks in Alberta Associated with the Sweet Grass Hills Intrusives

Potassium-rich igneous rocks of Eocene age (53 – 49 Ma), known as "Sweet Grass Intrusives," outcrop as plugs, small dykes and sills (up to a few metres thick), as well as volcanic rocks in the Milk River area of southern Alberta. They are the northern outliers of the Sweet Grass Hills intrusive complex of similar age that stands out as three prominent topographic features just to the south of the national border in northern Montana: West, Middle, and East Buttes.



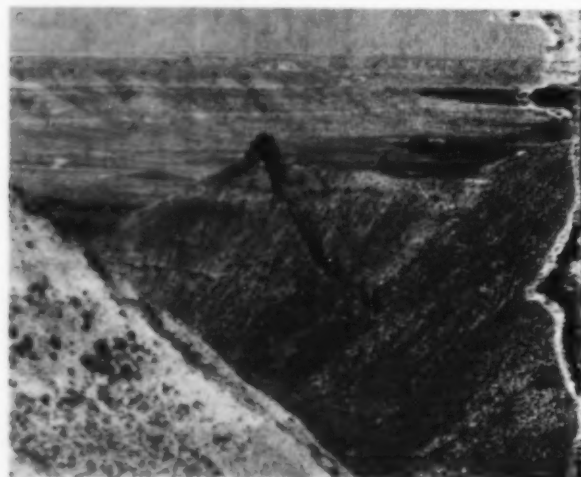
Sweet Grass Hills in northern Montana, USA. South-west view from Black Butte, southern Alberta.

Small intrusions have been also intersected in oil and gas exploration wells in the surrounding plains. Since the original geological description by G. M. Dawson in the early 1870s, these rocks have received much attention in research literature as well as exploration. Although diamonds became a focus of exploration in the area since the early 1990s, most of the previous search for metallic deposits concentrated on the intrusions in northern Montana. Despite the evidence for gold, silver, copper, lead, fluor spar and magnetite associated with the intrusions, and historical gold mining from both placer and lode deposits at Sweet Grass Hills, the potential for the intrusion-related precious and base-metal deposits associated with the "Sweet Grass Intrusives" in the Milk River area of southern Alberta remains poorly known.

As part of the ongoing revision of the provincial metallogenic inventory and development of an up-to-date systematics of the potential metallic deposits in Alberta, AGS conducted a reconnaissance field study and outcrop sampling of igneous and sedimentary host rocks in southern and southwestern Alberta in

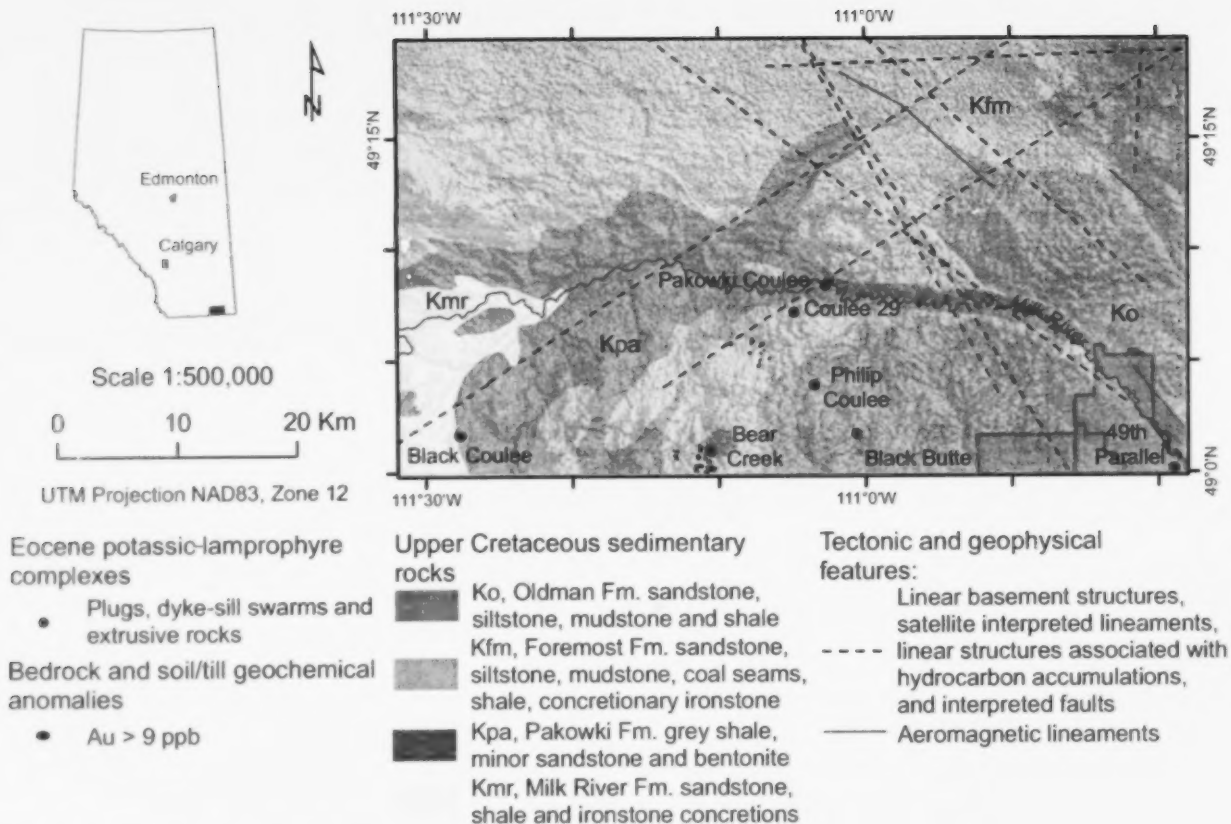
summer 2008. A summary with highlights of this study will be presented in a series of Rock Chips articles, each dedicated to a distinct episode of igneous activity during the Tertiary, Cretaceous and Mesoproterozoic. The detailed discussion of the results will follow as Open File reports. This article begins the series with a metallogenic overview of the youngest magmatic event that affected southern Alberta during the Eocene.

Eocene Potassic Lamprophyres in the Milk River Area, Southern Alberta



A south-east view of the Milk River valley with the Eocene potassic-mica-lamprophyre dyke cutting the Late Cretaceous shales, coal seams, siltstones and sandstones of the Foremost and Oldman formations at the 49th Parallel dyke swarm. The dyke is 1-2 m wide and has a general strike of 50°NE. At least three other dykes of similar composition outcrop within 100 m to the north-east of this spectacular intrusion.

Eocene intrusive and volcanic rocks cut Late Cretaceous clastic strata and are exposed at seven localities in the Milk River area of southern Alberta: the Black Coulee plug, Bear Creek dyke, Coulee 29 volcanic vent – dyke/sill complex, Pakowki Coulee plug-dyke complex, Philip Coulee dyke, Black Butte plug, and 49th Parallel dyke swarm. These brown, grey and black fine-grained rocks, often with abundant large crystals of brown mica, as well as entrained rock fragments of different size and composition, crystallized near or on the surface from a volatile-rich magma that originated by partial melting of mantle rocks at a great depth. On the basis of their mineralogy and geochemistry, all but one intrusive occurrence have been classified as "lamprophyres," with

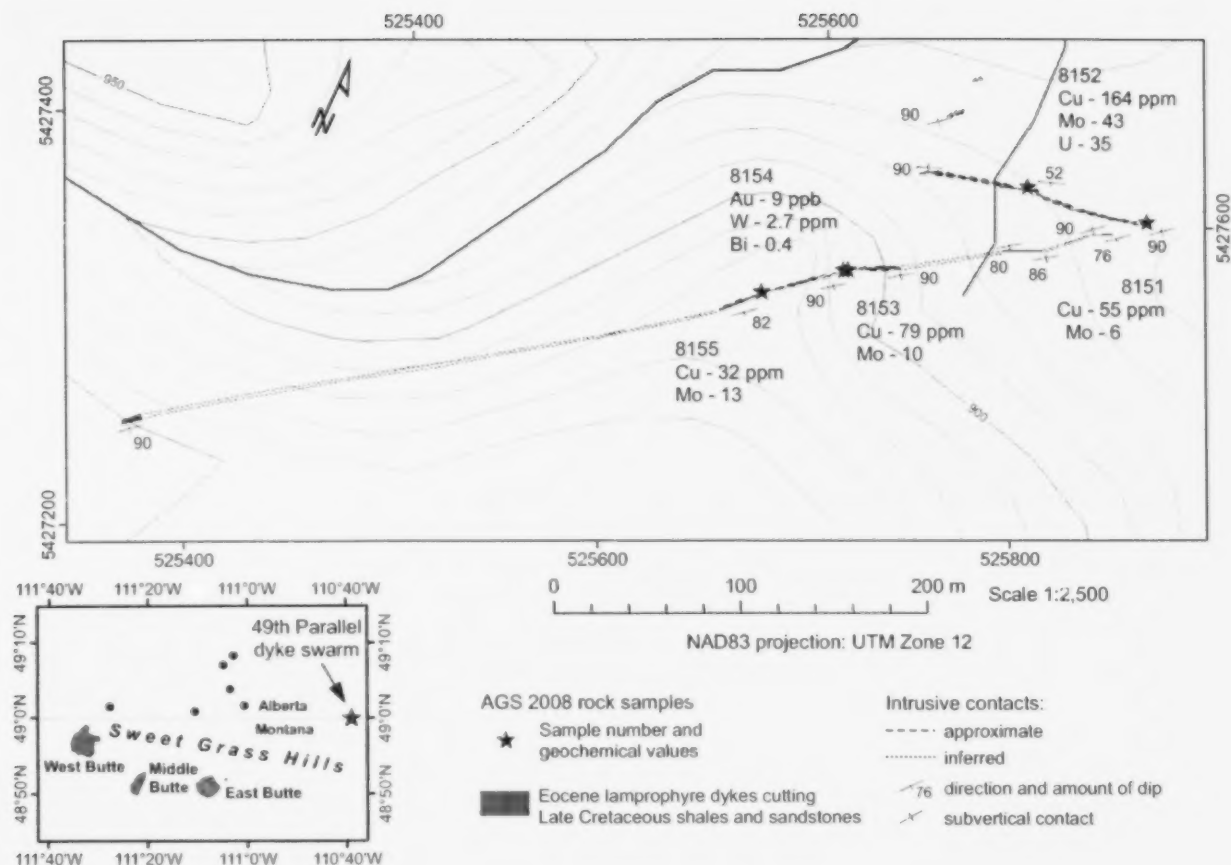


Geological map and the distribution of the Eocene potassic-lamprophyres of the Milk River area.



Close-up of the brown mica-lamprophyre from the 49th Parallel dyke. Note the abundant, large and glistening mica crystals set in a brown, very dense groundmass.

olivine-free "minettes" and "olivine minettes" being the most common varieties. Unlike the others, the Black Coulee plug is made up of a fine-grained grey rock with large hornblende and plagioclase crystals (1-7 mm long) that has been described as "diorite porphyry" or "andesite," suggesting an involvement of more than one type of magma. The same-age intrusives at Sweet Grass Hills, in the adjacent northern Montana, are associated with several styles of stratabound to structure-controlled, epithermal- to alkaline intrusion-related gold mineralization grading between 1.0 – 5.1 g/t Au at Tootsie Creek and Brown Eyed Queen mine (East Butte), Gold Butte (Middle Butte), and Grassy Butte. In the early 1990s, extensive soil and rock sampling programs, as well as ground and airborne geophysical surveys, were carried out to the south of the Milk River area in Alberta in the search for gold and diamonds. About 4% of more than 1000 analyzed samples returned ≥ 15 ppb Au and the highest volume of 65 ppb Au is significantly higher than the local background value of ca. 4 ppb Au. The enrichment in gold, coupled with arsenic, silver, antimony, mercury and base metal anomalies, was interpreted to suggest local epithermal and/or hot



Map of the 49th Parallel dyke swarm and location of the 2008 outcrop samples with distribution of some metals and pathfinder elements.

spring-type precious metal mineralization at Bear Creek. With all subsequent assessment work concentrated mostly on diamond exploration, no follow-up exploration for precious and base metals has been performed in the area. Nevertheless, regional airborne geophysical surveys flown in the mid-1990s indicate the presence of several linear magnetic and conductivity anomalies that were attributed to unexposed intrusions. In addition, there are several lineaments and faults that could have acted as conduits for mineralized fluids during the Eocene activity.

To further evaluate the metallogenic potential of Eocene potassic magmatism in southern Alberta, AGS carried out a reconnaissance mapping and sampling of five of the seven lamprophyre occurrences in July 2008: the 49th Parallel dyke swarm, Philip Coulee dyke, Coulee 29 dyke-vent complex, Black Butte plug and the Bear Creek dyke. Highlights of the total of 28 rock-grab samples include up to 164 g/t Cu, coupled with 43 g/t Mo, 35 g/t U and traces of PGE from a brown mica-lamprophyre dyke with rusty carbonate veins at 49th Parallel. There

were also up to 389 g/t Pb coupled with 382 g/t Zn and 0.5 g/t Ag in a float of vuggy carbonate vein encrusted with a few cm-wide calcite rhombohedra from a volcanic breccia of the Coulee 29 dyke-vent complex. Silty shale of the Late Cretaceous Pakowki Formation from a <1 m wide slab between the two *en echelon* offsets of the mica-lamprophyre dyke at 49th Parallel returned 9 ppb Au coupled with enriched W and Bi. Twelve of fourteen lamprophyre samples also show elevated platinum group element (PGE) contents of up to 5.9 ppb Pt and 5.3 ppb Pd. In addition, up to 12 ppb iridium was previously reported from the lamprophyres. These geochemical anomalies suggest the potential for alkaline intrusion-related precious and base-metal mineralization associated with Eocene potassic-lamprophyres in southern Alberta. ❖

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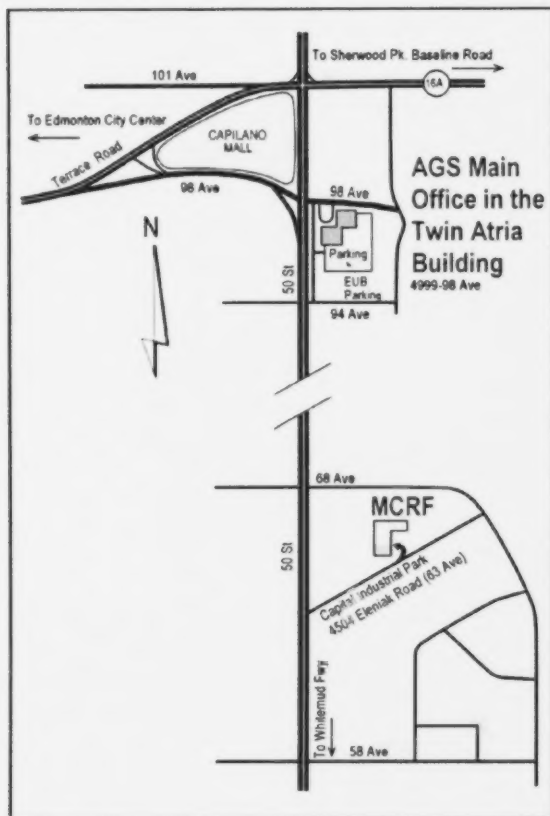
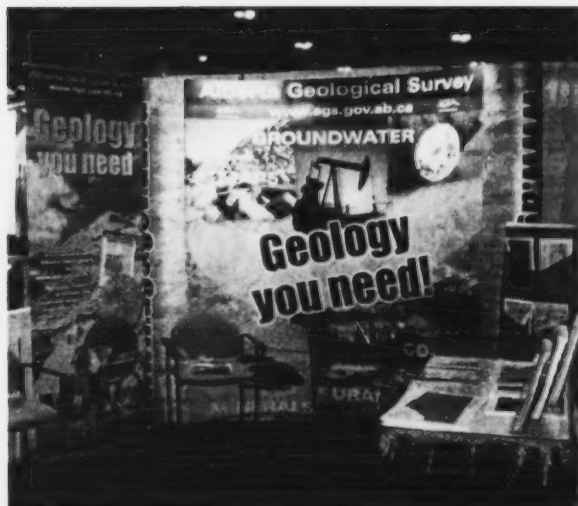
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Our Mineral Core Research Facility (MCRF) is located at

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